The Klondike and Yukon Goldfield in 1913

By H. M. Cadell, B. Sc., F.R.S.E.

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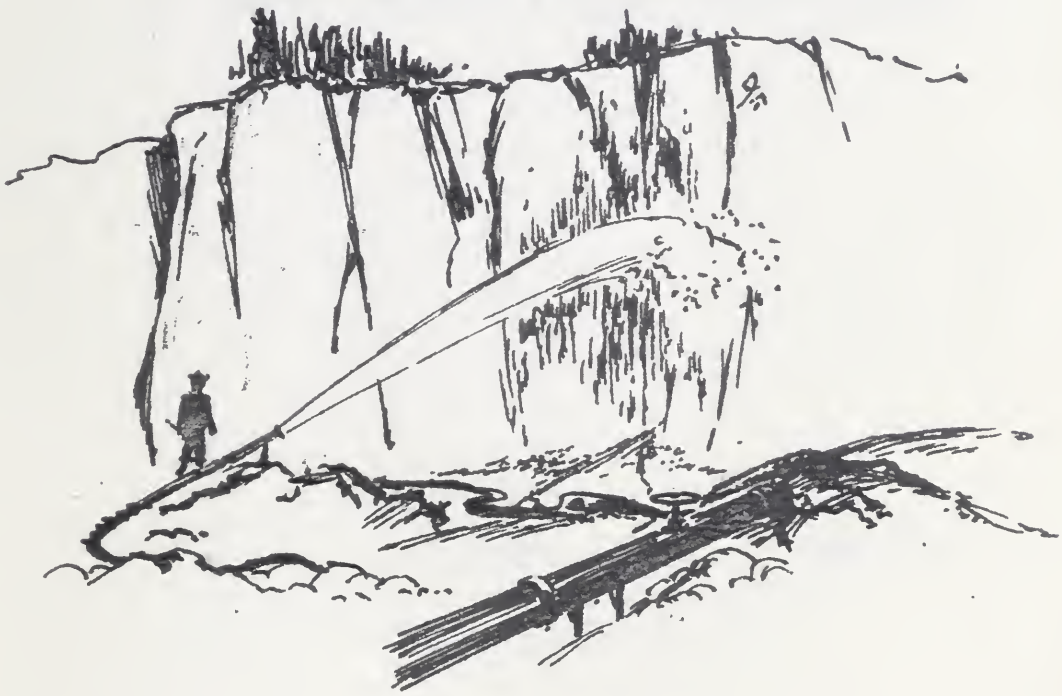

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THE KLONDIKE AND YUKON GOLDFIELD IN 1913.[1]

By H. M. Cadell, B. Sc., F. R. S. E.

[With 6 plates.]

Klondike was once a name in every mouth, and in the last years of the nineteenth century it nearly became incorporated in the language as a new synonym for all that is rich and prosperous. But of late it has been little heard of on this side of the water, and its early bloom has faded away. The sensational pockets of fine placer gold, that attracted hordes of hardy adventurers from every quarter, have now been mostly depleted and new ones have not been discovered to maintain the early reputation of the field. But while this part of the Yukon district can not any longer be called a poor man's goldfield, it still contains a considerable quantity of alluvial gold that can be profitably won by the application of capital and brains. In any case, it is a district well worth a visit, and apart altogether from gold it has other possibilities in the way of future development. Besides this, it is full of points of great geographic and scientific interest, and in this remote and imperfectly explored northwestern corner of the British Empire the geologist and the geographer will find many new problems awaiting them which it will be a delight to discuss and investigate for many years to come.

I had the advantage in September, 1913, of paying a short visit to the Yukon district with a few members of the International Geological Congress, under the able guidance of Mr. R. G. McConnell, of the Canadian Geological Survey, and other specialists and officials who had already explored the goldfield on behalf of the Government, and had published from time to time accounts of its industrial and geological development. We were thus placed in the favorable position of being able to see in a short time many things that might never have come under the notice of a solitary and unguided stranger, and with the literature and maps that were liberally provided it was possible to form a good general idea of the district, that might be made serviceable to our respective countrymen in distant lands, whether they might be men of science or people with more material interests.

[1] Reprinted by permission from the Scottish Geographical Magazine, July, 1914.

The Yukon territory is most easily reached by steamer from Vancouver through the lovely forest-clad islands and straits on the coast of British Columbia and the United States coastal belt of southern Alaska. In the last part of this most interesting voyage of nearly 1,000 miles the route lies along the Lynn Canal, a narrow arm of the sea that reminds a Scot of Loch Linnhe, but is bordered by higher mountains with snowy crests, and glaciers creeping down the glens to near sea level. The Lynn Canal is a straight fiord about 85 miles long, but it is only the prolongation northward into the mountains of the Chatham Strait, a deep submerged valley among large islands, whose whole length is 250 miles. The width varies from 3 to 6 miles, and the depth from 1,000 to 2,500 feet. Although this narrow inlet penetrates so far up into the mainland, its head, with that of all the other fiords on the coast north of the Portland Canal, now belongs to the United States. The latter claimed it, and Lord Alverstone as chairman decided in their favor and against Canada in the boundary dispute whose settlement caused so much bitterness in the Dominion in 1903. The head of the Lynn Canal lies at Skagway, the gateway to the Yukon, a wretched little town with decayed wooden houses and grass-grown streets, the scene of many robberies, riots, and murders at the time of the gold rush, which the police authorities outside of British territory had neither the power nor the energy to control. Skagway is not and can never be of much use to the United States, except as an obstruction to Canadian progress, but it might be of some advantage to the vast Canadian hinterland less than 20 miles inland. If, at some future time, the United States Government ever wished a cheap opportunity to show a little practical good will to their progressive northern neighbor, they might advantageously dispose of the head of the Lynn Canal, and thus give Canada one much needed outlet along a strip of some 500 miles of seacoast from which the Dominion has been cut off by the award of the lord chief justice.

Skagway is surrounded on three sides by a plateau of steep and rugged mountains through which to the north there are two trails, by the White Horse and the Chilcoot passes, respectively. Up these wild and difficult ravines thousands of hardy adventurers trekked and struggled with their heavy packs, tools, and tents, in the mad rush to the expected El Dorado, 500 miles away. Soon after the gold was found in sufficient quantities, a 3-foot-gauge mountain railway was laid up the White Pass (fig. 1). It runs from Skagway to the summit at 2,887 feet above sea level and on to Lake Bennett, a distance of about 40 miles. It traverses a wild, ice-worn, granitic plateau, strewn with moraines and sprinkled over with lakes at the foot of bare snowy peaks, 5,000 to 6,000 feet in height, reminding one of parts of the west coast of Sutherland or of the interior of Norway.

Lake Bennett, a narrow and picturesque sheet of water between high mountains, is 27 miles long and its outlet at the northern end is one of the tributaries of the Great Yukon River. The sixtieth parallel, that of the south end of the Shetland Islands, crosses the lake some miles from the deserted town of Bennett at its head. At the time of the gold rush there were 5,000 people at Bennett in houses, huts, and tents, and the fact that a wooden Presbyterian church was built there shows that more than 10 righteous men were to be found among that surging and sordid crowd. The church is now almost the only building besides the railway station that is standing, but it is boarded up and falling into decay. The photograph I had time to make during our short halt for lunch shows this little ecclesiastical pile with its spire pointing to the sky adding a human touch to the grand but desolate picture (pl. 1).

FIG. 1.—Scenery at summit of White Pass, on Yukon Railway. Altitude, 2,800 feet.

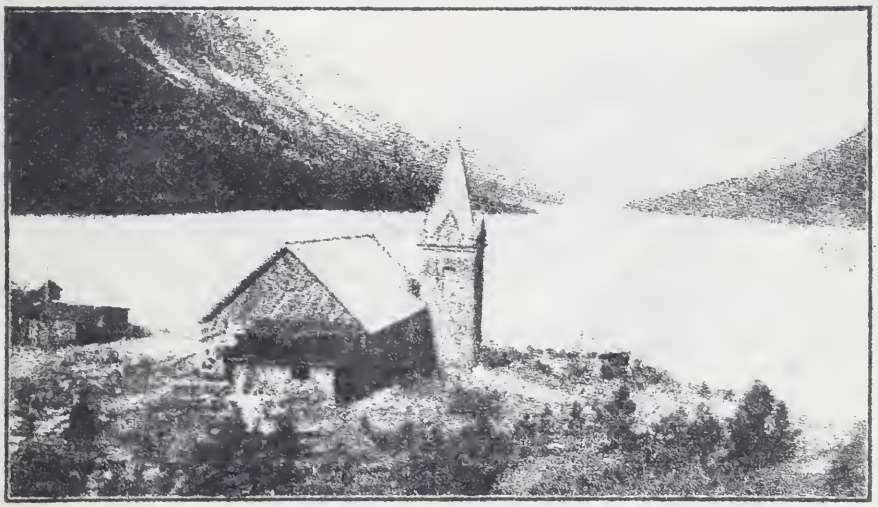
The original diggers here got into boats and canoes, and navigated their frail craft through the lakes and rapids on the remaining 531 miles of their adventurous journey to Dawson City. The whole distance from Skagway to Dawson is 571 miles, and the first part of the journey is covered by 110 miles of railway. The line runs at the foot of the steep granite mountains along the shore of Lake Bennett to White Horse, a few miles above the tame but beautiful Lake Laberge, where safe navigation begins. At the north end of Lake Bennett the country becomes less rugged, and the mountains lower and more rounded, and there are broad valleys covered with glacial drift and herbage. Lake Laberge is a little over 2,000 feet above sea level and the whole fall to Dawson is about 1,000 feet, which gives an average gradient in 435 miles of a little more than 2.5 feet per mile. There are no serious declivities below White Horse, and only at one place—the Five Finger Rapids below the Tantalus coal mine—is there much risk to travelers during the season when the river is open to navigation by flat-bottomed, stern-wheel steamers.

The Lewes River, flowing from Lake Laberge, and the Yukon, of which it is a large tributary, flows northward in a channel with many windings between high terraces of gravel and sand. White Horse is situated on the flat river bank at the base of one of these high gravel terraces, well exhibited in plate 1. The upper part of the valley is full of glacial detritus and fine mud from the glaciers that once covered the higher country, and the river is busy excavating a lower channel in these loose deposits. Over a large district the sandy soil under the grass has a skin of impalpable white ash from 6 inches to a couple of feet deep, that has been wafted hither at the time of some prodigious eruption of an unknown volcano long ago, and has fallen quietly like a shower of fine snow over the face of hill and dale.

Though the latitude is that of our Shetland Islands, this part of the Yukon Valley is thickly covered with trees, mainly aspen, birch, alder, and spruce. In the bright September days the whole landscape was blazing with the brilliant golden and scarlet tints of the autumn foliage, mingled with the somber hue of the firs in the lower reaches, and this mass of rich coloring faded away into the deep blue and purple of the bare mountain crests in the background of the lovely picture.

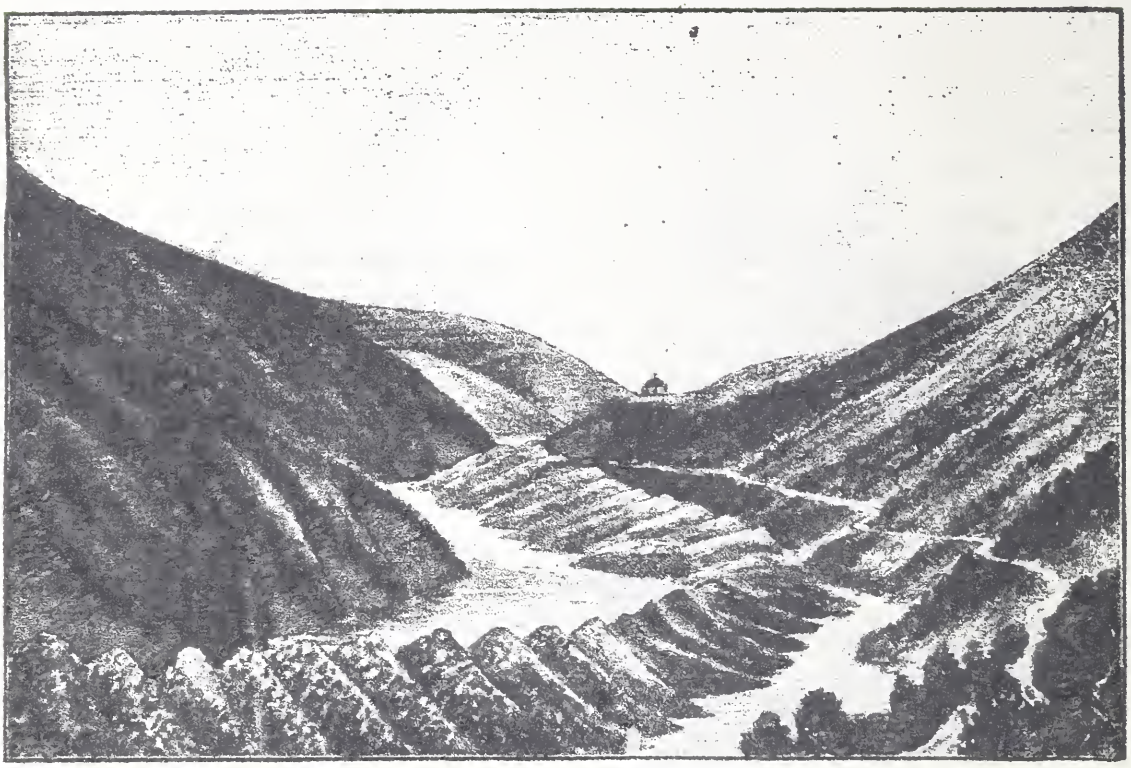
Many kinds of rock are to be found along the Yukon Valley, from pre-Cambrian schists to Tertiary and recent volcanic lavas. At Tantalus, where the Nordenskiöld joins the Lewes River, 200 miles below White Horse, and at the Five Finger Rapids some miles farther down, seams of coal are seen cropping out on the cliff faces. Although there is much true Carboniferous limestone in the district, this formation is not associated with any coal, and, as is the case all over western Canada and Alberta, the coal is all of younger age, and is interbedded with Jurassic and Cretaceous strata. The seams are sometimes over 7 feet thick, and at Tantalus there is a mine in operation in the cliff at the river's edge where several thousand tons have been worked. The coal is of great use, as the woods near the river have been largely cut for fuel and for mining and building purposes, and the supply is thus becoming scarcer every year. But the quality of the coal is not very good, and its percentage of ash is high.

Near White Horse a valuable body of copper ore is also being mined in the hills, and if enough good coal were to be discovered a great impetus would be given to permanent local industry of a better kind than precarious gold mining. The region has for half the year at least a good and sunny climate, and as it is now fairly accessible it may some day develop into a useful grazing or agricultural territory. It is, of course, still largely unexplored, and more valuable minerals and other resources may yet be discovered in the unfrequented remoter hinterland out of sight of the river highway.



LAKE BENNETT.

THE LEWES VALLEY AT WHITE HORSE, SHOWING HIGH TERRACE OF GLACIAL GRAVEL.



A "HUMAN MORAINE." EFFECT OF GOLD DREDGING ON TOPOGRAPHY OF HUNKER CREEK, KLONDIKE.

EFFECT OF HYDRAULIC SLUICING OF UPPER WHITE GRAVELS, BONANZA CREEK, KLONDIKE.

A curious and interesting feature of the district must now be mentioned. The numerous lakes, the deeply eroded ice-worn valleys, and the widespread deposits of gravel and morainic material in the upper part of the Yukon Basin, all tell of the former wide extension of the glaciers, whose diminished representatives have long ago shrunk back into the remote glens and corries among the higher mountains. But as we sail northward toward the Arctic Circle these traces of former extensions of land ice diminish, and finally disappear altogether. The moraines are no longer to be seen, and all we find in the valley is a wide deposit of very fine sand or silt, such as is washed in a milky flood from beneath any valley glacier. These glacial silt beds finally dwindle away, and the solid rock surface becomes soft and rotten, and covered with screes and loose débris produced entirely by its own disintegration.

Long before we reach Dawson all traces of glaciation have disappeared, and the noble river winds back and forward between the steep sides of a valley, a quarter of a mile wide, cut out of the old and decomposed plateau of crystalline rocks. The latitude of Dawson City is that of the south of Iceland, and its level is a little more than 1,000 feet above the sea. The whole of the old alluvium in the valley bottoms is frozen hard to a depth of over 100 feet, and the summer sun is only able to thaw a few feet of the surface before the winter's cold sets in, and the whole region is incased in snow and ice.

Now, it is a matter of common knowledge that the cold was at one time so intense in the Northern Hemisphere that the northern parts of Europe and Canada were covered for a time by huge glaciers, or ice caps, such as now envelop the whole of Greenland. The whole of the Pacific coast of British Columbia and the southern end of Vancouver Island is intensely ice worn. In the eastern part of Canada the polar ice cap in the glacial period covered the country as far south as the Great Lakes, and left the Province of Ontario sprinkled over with clay and stones from far-off northern sources. Wherever the great ice sheet went it swept away all the loose rock, river alluvium, and soil that lay on the preglacial land. The underlying rocks were scoured and polished, and when the ice melted at last, the valleys and plains were left buried under a covering, not of soil or river alluvium in stratified beds, but mainly of unstratified bowlder clay or till, produced by the grinding of the creeping ice, which was at places thousands of feet in depth.

These considerations may seem remote from the subject of the Klondike gold deposits, but in reality the opposite is the case. The original valley gravels, the accumulations of long ages in which small quantities of gold derived from the adjacent rocks had become collected, sorted out, and concentrated by the long-continued action of the ancient rivers—these auriferous deposits were not swept away

here as they were at other places during the glacial age, and they were only partially washed out by the rivers of later times. They were left, or at least partially left, lying undisturbed in certain sheltered valleys until their value was discovered by a few prospectors. The final process of removal, or at least disturbance, of the old gravels was not long delayed after this important discovery had been made.

The reason why this northern territory thus escaped the besom of destruction that swept other regions bare was doubtless the fact that the climate was so dry that there was little or no rain or snow to produce a great glacier. However great the cold may be at any place, it is obvious there can be no frozen water if the water is not first there to freeze. Had there either been no ice age, or else a dry climate during that epoch, placer deposits of gold might also be found in eastern Canada, Scotland, or Scandinavia, where small quantities of the precious metal occur in the local crystalline rocks, and the almost complete absence of alluvial gold is one result of that prolonged icy invasion of these countries. The deeply frozen subsoil in the Klondike district is all that remains to tell us of the great cold of the glacial age, for there is no doubt that the ground has remained in a frozen state since that period, and that its covering of moist peat has effectually prevented it from becoming thawed by the warm sun in summer.

The Yukon goldfield, so far as it has been explored, is apparently mainly confined to the vicinity of Dawson City, although small quantities of gold can be found in the sand of the Yukon for hundreds of miles up the valley. Indeed, our party panned a little gravel and got specks or colors of gold where the steamer stopped for fuel, 10 miles below Big Salmon River, a tributary of the Lewes River above Tantalus, near the place where gold was first discovered in 1881. We passed an old digger who, we were told, can wash out about £2 worth of gold a day during good weather, when the water is low and the banks well exposed, in certain parts of the channel.

Dawson City (see map, fig. 2) is situated on the alluvial flat close to the mouth of the Klondike, a small river which rises in the Ogilvie Range and flows southward and westward into the Yukon. The Bonanza Creek is a little stream in a deep and wide gully that enters the left bank of the Klondike Valley just above the confluence at Dawson, which is celebrated for the richness of its auriferous gravels. The Klondike is joined by two other tributaries on its left bank farther up, Bear Creek and Hunker Creek, the latter of which is by far the larger and more important. These and other streams all occupy smooth-sided valleys traversing an old peneplain or dissected upland composed of rounded hills and ridges. These smooth ridges originate in and branch outward from the Dome, a round-topped eminence

reaching to an elevation of 4,250 feet, the highest mountain and topographic center of the whole district. It is 19 miles southwest of Dawson and commands a magnificent view of the surrounding tract of brown, grassy uplands, sweeping away northward for 40 miles to the snowy peaks of the Ogilvie Range. I had time to make a topo-

FIG. 2.—Map of Klondike district and vicinity. (From the Geological Survey of Canada.)

graphic sketch of the panorama from the summit, which was nearly clear of snow, and have now reproduced part of it to convey to the reader an impression of the general appearance of that remote and lonely region, the haunt of the caribou and the ptarmigan. (See pl. 3.)

The Klondike goldfield has two perfectly distinct sets of placer deposits. In the allu·ial flats of the Klondike and its tributaries, the

Hunker and Bonanza Creeks, there is a series of deep gravels covered with soil and peat moss and containing the remains of extinct and existing animals in large quantities. Bones of mastodon and huge mammoth tusks, skulls of buffaloes and bones of bear, musk ox, and mountain sheep, as well as ancient beaver dams, are often discovered by the drift miners. These ancient denizens of the valleys must sometimes have been of immense size. I met a digger from another gold field in Alaska who told me that he had once seen a mammoth's tusk 14 feet long in the frozen gravel, but those found in the Klondike district have seldom a length of more than 11 or 12 feet.

In these gulch or valley gravels the richest gold is found, and the most valuable part is at the bottom next the bedrock. To reach the pay streak shafts have to be sunk where the gravel is deep, and the fact that the ground is all frozen makes the drift mining a comparatively easy operation requiring very little timbering or pumping.

The second set of auriferous gravels occurs at certain places on high terraces or benches cut in the rock, and they reach up to about 450 feet above the beds of the existing valleys. These high-level gravels are mostly white or pale in color, very compact, and quite different in appearance from the loose and more recently formed low-level placer deposits. They are largely made up of white quartz pebbles and sand and subangular pieces of vein quartz and sericite schist. The largest bowlders are seldom more than 18 inches in diameter except near the bottom, where large angular blocks 3 or 4 feet in diameter are occasionally found. The white channel gravel is very uniform in texture and reaches a thickness at places of 150 feet, with a maximum width of more than a mile. It is almost unstratified and, unlike the valley gravel, is totally destitute of plant or animal remains. At the bottom of the white gravel there is a pay streak next the rock. This is at places extremely rich, but gold occurs throughout the whole bed in quantities sufficient to be profitably extracted by hydraulicking, but not by individual miners. The best of the pay streak has been already exhausted by drifting, and what is left is being worked by hydraulic "giants" in the hands of capitalists.

These two distinct river deposits have an interesting story to tell. They point unmistakably to a change in the level of the land at one period, and indeed when the Yukon territory comes to be better explored many other interesting historical points that are now obscure will be cleared up. There is evidence of a considerable change in several parts of the Yukon River system since the Tertiary period, and some of the rivers have been able to capture parts of others and so modify the original pattern of the continental drainage. The land has not remained quite stationary, and indeed in Yakutat Bay, in Alaska, as recently as 1899, there was a terrific earthquake, accom-

panied by a local movement of the land and an upheaval of the coast line to the extent of 47 feet in one place.

In the Klondike and Dawson instance the movement was one of upheaval of the whole region to a height of at least 700 feet. There were ancient river valleys with sluggish streams, where the white terrace gravels slowly accumulated and in whose bottoms the grains of gold derived from the waste of the small quartz veins in the neighboring hills became concentrated in streaks and pockets. When the uplift began the rivers acquired fresh velocity and started at once to deepen their old courses energetically and to cut out new and narrower valleys in their old flood plains. They swept away a great deal of the white gravel, but some of it was left undisturbed, with the gold-bearing streak beneath. The process went on till the rivers had not only cut out deep trenches in the white gravels, but had penetrated far below them into the underlying rock. The gold in the white gravels, perhaps with other gold derived directly from the neighboring schistose rock, sank to the bottom of the later alluvium and was concentrated again in a newer pay streak, while the lighter débris was mostly transported to the distant sea. The climate was mild enough for vegetation to flourish, on which many large animals browsed in peace and comfort, or were preyed upon by more predaceous denizens of the northern wilds.

To come down to more modern times, adventurous prospectors threaded their weary way over this little-explored region, and these hardy pioneers of empire first began to find traces of gold in the Yukon Valley about the year 1869. In 1881 gold was found in the gravel banks and bars of the Big Salmon, and other discoveries were made in the Lewes, Pelly, and Stewart Rivers soon afterwards. The first discovery of coarse gold was made on the Fortymile, another tributary of the Yukon below Dawson, in 1886, and with this evidence of the auriferous character of the district prospecting received further encouragement. In 1894 fresh discoveries drew the miners into Klondike Valley, but it was not till 1896 that the great find was made, of which I shall now give a short account.

In 1894 Bob Henderson discovered gold in Quartz Creek, a tributary of Indian River, at a place about 6 miles south of the Dome, and he went over the ridge to Gold Bottom, another gully, a tributary of Hunker Creek, where he discovered more gold in 1896. He told George Cormack, another prospector in the district, of his luck, and Cormack paid him a visit, but on the way back Cormack, or one of his companions, while stopping for dinner, accidentally turned up some remarkably rich dirt at Bonanza Creek, and immediately pegged out a claim without ever telling Henderson of his own far greater luck.

Prodigious quantities of gold were soon found at this spot, and prospectors flocked in from all quarters. Many of them made fortunes

in a short time, but not being educated to use wealth properly, it was mostly misused and spent in debauchery. The greatest quantity produced in the district was in 1900, when the output reached nearly four and a half million pounds sterling. One man, Dick Lowe by name, is said to have got out of a fractional claim, 86 feet by 300 feet in area, £120,000, but I was told he spent it in a few years and died in poverty. Others got and wasted as much or more. Cormack was said to be working as a coal miner and Henderson was in 1913 a Government pensioner. One of the quickest fortunes was made by two men who in 27 hours cleaned up gold to the value of £13,000. Many stories are told of the proceedings at Klondike in these "golden days" which are not for edification, and the moral is that wealth too easily and quickly acquired is apt to be the opposite of a blessing to mankind.

At the height of the boom in the winter of 1899 the population of Dawson City is said to have reached 25,000, and that of the whole district 50,000. All these people did not make fortunes, while many lost their lives in the attempt, and soon the richest of the placers became exhausted and the exodus began. At the time of my visit Dawson City had a population of only 2,000, and the place was in a sorry condition, while the surrounding district was almost depleted of drift miners.

When good gold was found the Government, out of the revenue from the duty that was paid, set to work with exemplary speed to construct roads up the main creeks and over the hills, which greatly facilitated and cheapened transport. We went up Klondike Valley and Hunker Creek by one of these roads, spent the night in the little rest house near the summit in the snow that had begun to fall, and next day returned by Eldorado and Bonanza Creek. My little party of three was fortunate enough in being conveyed round this 60-mile run by Mr. J. W. Boyle in his motor car, not without considerable difficulty and risk at perilous places. Mr. Boyle is the able head of the Boyle Concessions (Ltd.), one of the two large and prosperous companies now engaged in extracting the remaining gold left by the drift miners. Besides showing us great hospitality, Mr. J. W. Boyle, in common with many other kind hosts in Dawson City, gave the visitors much valuable information about the present condition of the gold industry and the methods that are taken to succeed in accomplishing by modern science and capital what in the hands of poor and uneducated men would be a perfectly hopeless task.

The gold in the Yukon field is, as has been said, derived originally from many small veins widely disseminated in the metamorphic schists of the surrounding locality. Large and productive veins have not been found but attempts have been made to work small

ones, hitherto, however, with indifferent success. The long-continued operations of nature before the advent of man have been needed to concentrate these scattered grains into sufficient quantities to be profitable for his use.

The various methods of gold recovery in the Klondike district may be generally classified under three main heads into the following seven subdivisions:

A. By individual men:
   (1) Washing surface gravels with shovel and pan.
   (2) Sluicing gravel with flumes and sluice boxes.

B. Small parties:
   (3) Working drift with mechanical scraper and sluices.
   (4) Drift mining in shafts and sluicing.

C. Capitalists:
   (5) Dredging with powerful mechanical plant.
   (6) Hydraulic sluicing with monitors.
   (7) Mining and stamping ore in mills.

The first class (A) includes the so-called "poor men's diggings," as all the plant that is required are a few tools and wood to make

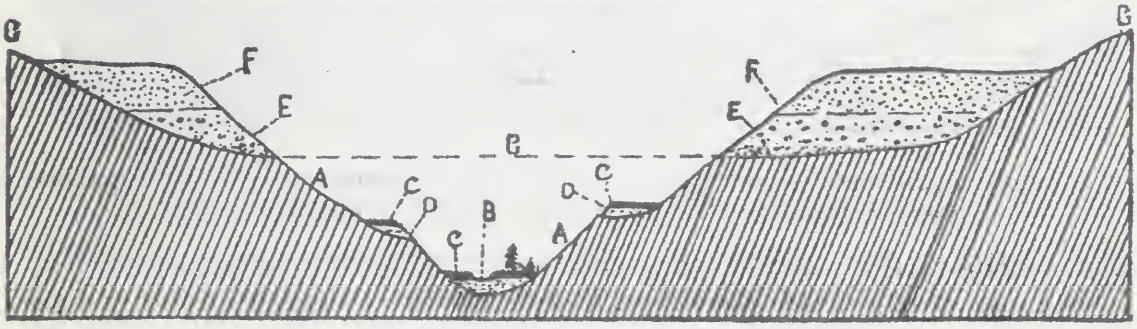


FIG. 3.—Generalized section showing distribution of auriferous gravels at Klondike. *A*, Klondike schists; *B*, stream gravels; *C*, peat or "muck"; *D*, terrace gravels; *E*, white channel gravels of old valley; *F*, high-level gravels; *G*, *G*, *G*, profile of old valley bed.

cradles or sluice boxes and flumes to convey the water required to wash the gravel. The second class (B) requires more financial resources and also more mechanical ability, but a man who has begun from zero may, if successful, quite well gain enough money and experience to enter class B and employ other men or work in company with a party on the cooperative system. Both A and B, however, require fairly rich ground to work upon. But between B and C there is a wide gap, and only men such as Mr. J. W. Boyle, with exceptional ability and command of ample capital, can hope to pass from B to C and work the low-grade placer gravels or quartz veins successfully. The poor men without education who suddenly realized fortunes, but had not the brains to use their money rightly, were not qualified to pass into the last class even though they had the capital to begin with. The survivors, the men with both the mental and material resources, are now left almost alone on the field, and it is to them that the future of Klondike belongs.

On our way up Klondike Valley, between Bear Creek and the mouth of Hunker Creek, we stopped to visit the last of the old drift mines in the Klondike Valley, where a party of 21 men were working on tribute in the frozen gravel, which is here 40 feet deep, for which they paid a royalty of 20 per cent of the gold recovered to the owner of the claim. The accompanying diagram, showing a section of the working drawn to scale, and a sketch of the surface arrangements (pl. 4), will convey an idea of the method adopted in this field by miners with a limited amount of capital at their disposal.

A shaft is sunk to the rock surface where the pay streak occurs, and from this a tunnel or heading is driven 50 yards in one direction to the boundary of the claim or the limit of the little field that can be worked easily from one shaft. When this distance is reached a drift is made in the gravel at right angles to the main tunnel on each side along the boundary, so that the working plan is like the letter T to begin with. Then the whole area is gradually worked back

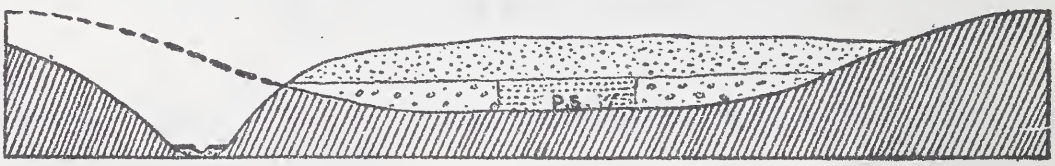


FIG. 4.—Section across Bonanza Valley at Lovett Hill (vertical scale double horizontal). *P. S.*, position of pay streak of coarse gold at bottom of white channel gravels in bed of old valley.

toward the shaft on a method corresponding to what in coal-mining is known as the "long-wall system." It is not a true long-wall method, however, as no wall is required to hold up the frozen roof, which is very strong and needs no support near the working face. In mining a coal seam the thin "holing" picked or cut out under the coal is the least valuable part, and the thick stratum above it is what the miners are after. But in the case under notice the opposite principle holds. The thin stratum next the bedrock is the only valuable part. It is, however, too hard frozen to be immediately removed. To undercut the hard mass, lines of horizontal holes are bored close to the bedrock into which pipes with sharp points are driven 4 or 5 feet, and connected with a pipe from a boiler at the pit mouth. Steam is thus injected by means of these steam points, as they are called, for from 6 to 12 hours, and the holing is thawed till it is quite soft and can be easily excavated with picks and shovels. Each steam point requires steam equal to about one horsepower, and thaws from 1 to 3 cubic yards per shift. This thawed gravel is wheeled away in barrows and emptied into a bucket or skip at the pit bottom. The bucket is hoisted to the surface by a steam winch, and by an ingenious arrangement travels along an aerial ropeway and is tipped automatically into the sluicebox. All the surface labor required is that of a man in the sluicebox to throw

out the stones and another to attend to the engine. In order to give headroom for working, the gravel thus undermined is broken down in lumps and thrown back into the waste, and the loose stuff fills it nearly to the roof. In course of time the superincumbent stratum thaws and subsides gently like the roof of a long-wall working, and closes up the space above the waste, and the surface of the ground sinks down to the same extent

This frozen gravel or "muck" provides a surprisingly strong roof to the working. It is, however, sometimes forgotten that water is a true mineral, and in its crystalline or frozen state is as much a rock as granite. When thus solidified in the interstices between hard grains and pebbles it forms a very strong and homogeneous block without fissures or joints to weaken it or interrupt its continuity. Thus it is that drift miners can work with comparative safety, especially in winter, and only require to leave an occasional solid pillar or put in a little timbering to support parts of the roof that may be weak. In winter time the frost is most intense and the roof not so liable to fall in. In one case on Dominion Creek, a "muck" roof of this kind, unsupported by pillars, is stated to have covered a vault 140 feet wide by 230 feet long, and remained unbroken till midsummer.

The thawing of the gravel was originally carried on by wood fires placed against the face like the ancient method of fire setting to disintegrate the lode in metal mines before the days of explosives, but the use of steam points soon superseded this primitive process. There is, of course, considerable danger of individual stones or slices of the roof dropping down, and fatal accidents have often occurred from this cause. In the mine I have described I noticed a continuous slight shower of sand grains dropping on my head from the thawing skin of the roof, but happily no large hailstones were among them.

The depth of the frozen ground is variable, and is less on the ridges than in the valleys. A shaft sunk on the ridge south of Eldorado Creek reached unfrozen ground at a depth of 60 feet, while one in the valley of the same creek was stopped by running water at a depth of a little over 200 feet. The advantage of the ice is thus obvious from the point of view of pumping, which, if it became necessary, would put an end to many of the poorer drift mines in the valleys. But for surface work the ground must be thawed artificially when the gravel comes to be handled on a large scale at a depth not affected by the summer sun.

The bed of peat, or "muck," as it is called, that covers the valley bottoms acts as a nonconducting skin and prevents the sun's rays from penetrating the frozen mass, but when it is cleared off the surface thaws permanently to a depth of several feet, and can be removed by a scraper and sluiced or otherwise treated.

We now come to the more important methods of gold recovery by which the output of the field is being maintained after the drift miners have extracted all that is possible by their simple and inexpensive appliances. There are, as we have seen, two kinds of gravel, one in the valleys and the other on the high terraces, and to extract the remainder of the gold two separate methods must be thus employed.

The valley gravels are worked down to a certain depth by very strong and specially constructed dredgers, with internal revolving trommels or screens, and extensive sluice boxes with the usual riffles to catch nuggets and gold grains. The terrace gravels are removed by hydraulic giants, and washed through flumes and sluice boxes into the already depleted valley bottoms, and when all these complicated operations are completed the physical character of the gullies is completely changed.

The dredging operations are mainly conducted by two companies. One of these is the Boyle Concessions (Ltd.), and the other the Yukon Gold Co., the principal partners in which are the Messrs. Guggenheim. The Boyle Concessions (Ltd.) has taken over the holdings of the Canadian Klondike Mining Co., and controls and operates the properties of the Bonanza Basin Gold Dredging Co. and the plant of the Granville Power Co. The company has holdings on the Klondike Valley and other creeks, covering altogether about 40 square miles, and at present its operations are confined mainly to dredging the valley gravels. The Yukon Gold Co. has both dredgers in the valleys and hydraulic monitors at work in the upper white gravels.

The dredging process is an interesting and remarkable one, and produces curious effects. To wander up a lone glen with a mere trickle of water in it, and suddenly to come round a corner and confront a solitary large dredger, grinding away among peat bogs, wooden huts, and old dump heaps, is a surprising apparition to one who always associates dredgers with docks and navigable estuaries. But this is what can be seen in several creeks and dry gulches amid the Klondike hills. The plant is transported piecemeal, with great labor, to the patch of alluvium where it is required; a large square hole is then dug in the ground large enough to float the structure, and there it is put together, built up, and set agoing. The buckets scoop out the gravel at one end, and the stones and sand are dropped out in a bank behind at the end of a long conveyor, while the fine mud runs out by a separate orifice. This pond or tank is thus part of the working plant, and the dredger slowly carries along with it the water on which it floats, as the original stream is far too small to support the massive hulk. All the water in the stream is, of course, required to help in keeping the basin full, and to prevent its fluid from becoming too thick in conse-

quence of the sediment that is being constantly washed out of the gravel.

The final result of the operation is that the flat bed of gravel as far down as the dredger buckets can reach—perhaps 60 feet at the outside—is cleaned out, and all sorted into a deposit of coarse shingle, with bowlders at one place and fine silt or sand at another. The gully, if narrow, after being robbed of its gold is thus left with a long embankment of stones, ribbed from side to side with deep furrows corresponding to each forward step of the dredger, and running up the glen in a serpentine course for miles, perhaps, like a moraine left by a valley glacier (pls. 2 and 6).

This "human moraine" heap entirely blocks up and interrupts the course of the original stream, and produces a series of more or less stagnant pools in the loops it makes in its meanderings between the sides of the gully. If the latter is broad, there may be two or three parallel embankments, with pools of muddy water between them, amid which the stream has to find its way past as best it can. The mud that is washed out in the process lodges in these lagoons and buries up the bases of the stony ridges. Plates 2 and 6 show this curious physiographic effect of the valley dredgers, an effect that will last for centuries, and one that has probably never been taken notice of before. This, however, to anticipate matters, is not everywhere the final result of man's geological work on the Klondike River system.

First, the drift miners swarm in multitudes, like locusts, undermine the gravel, and turn it upside down. After they have disappeared the dredgers arrive and slowly plow it all over again, throwing it into great ridges of stones, with mud banks between. Finally, at those places where there are white gravels on the high ground, the hydraulic "giants" appear on the scene, wash them down in great cones of dejection vomited forth at intervals from the flumes on the mountain side. These white deltas radiate outward like fans, and sometimes reach across the entire valley, when they completely bury all that is below. By thus damming up gullies and producing new lakes they end in completely drowning and obliterating the effects of the previous dredging and drifting operations. When the geologist of the remote future comes to unravel these complex valley deposits he will have a tough problem before him, unless he has previously well acquainted himself with the achievements of the singular beings who inhabited these glens in a far-off age, when the hunt for yellow gold was apparently considered the ultimate aim and end of their whole existence. (See pl. 2.)

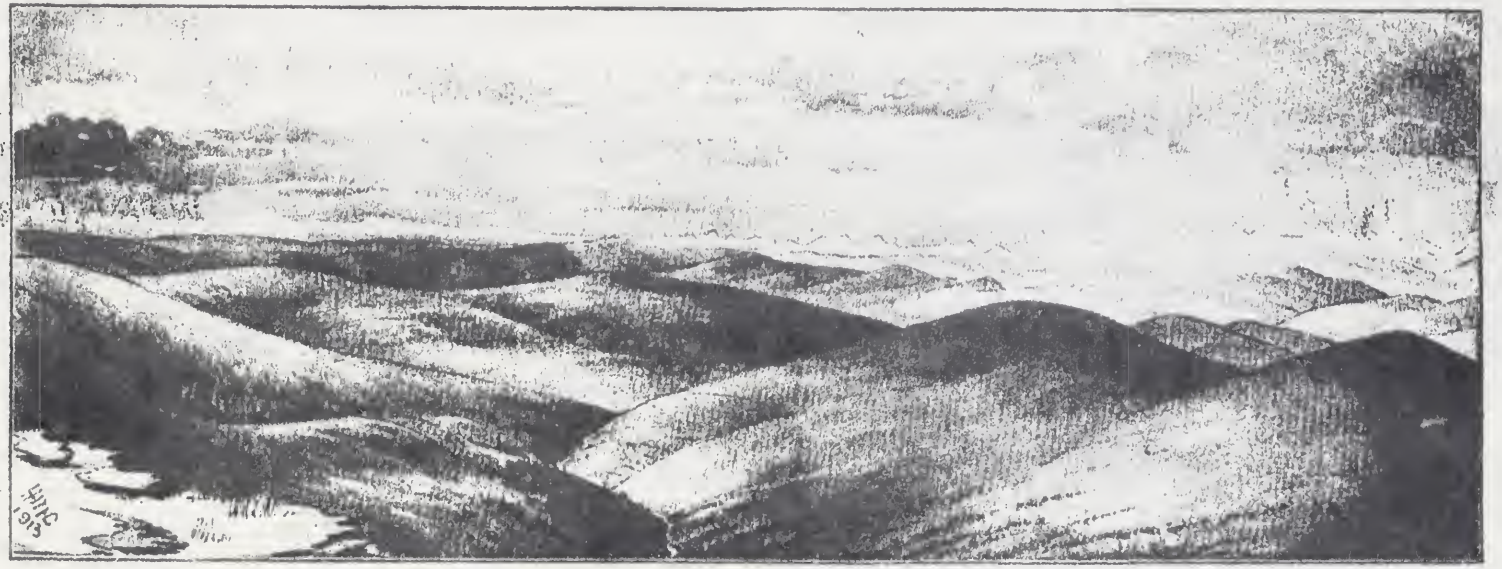
There are many dredgers of various sizes at work. The largest and newest, "Canadian No. 3," belonging to the Boyle Concessions (Ltd.), which started on March 31, 1913, was working close to Dawson City at the mouth of the Klondike Valley at the time of our visit. (See

pl. 5.) It is an immense structure weighing some 2,000 tons and cost nearly £100,000, but its efficiency is marvellous. It dredges 11,300 yards per day and goes Sunday and Saturday for 250 days a year from March till nearly Christmas, when the weather becomes too severe. The buckets scrape all they can reach, including blocks of the bedrock, and to test their efficiency we are told that a man twice threw a small coin about as large as a threepenny piece into the water, and each time it was brought up and recovered in the riffles along with the gold. The whole machinery is controlled by one man, the dredge-master, who has 10 men under him—3 winchmen who are paid $6 (25s.) a day; three oilers, at $4.50 (18s. 6d.), and 4 deck hands, at $4.80 (about 20s.). The winchmen and oilers work in three shifts of 8 hours, and the deck hands two shifts of 12 hours. The cost of dredging a cubic yard is 6 cents (3d.), and the average value of the gold is 28 cents, so that the gross profit is 22 cents (11d.). On the 11,300 cubic yards dredged this gives a daily gross profit of a little over £500, so that it is obvious with gravel of this value there is a very handsome annual return, and indeed it would pay well to dredge much poorer stuff, of which no doubt there is still abundance.

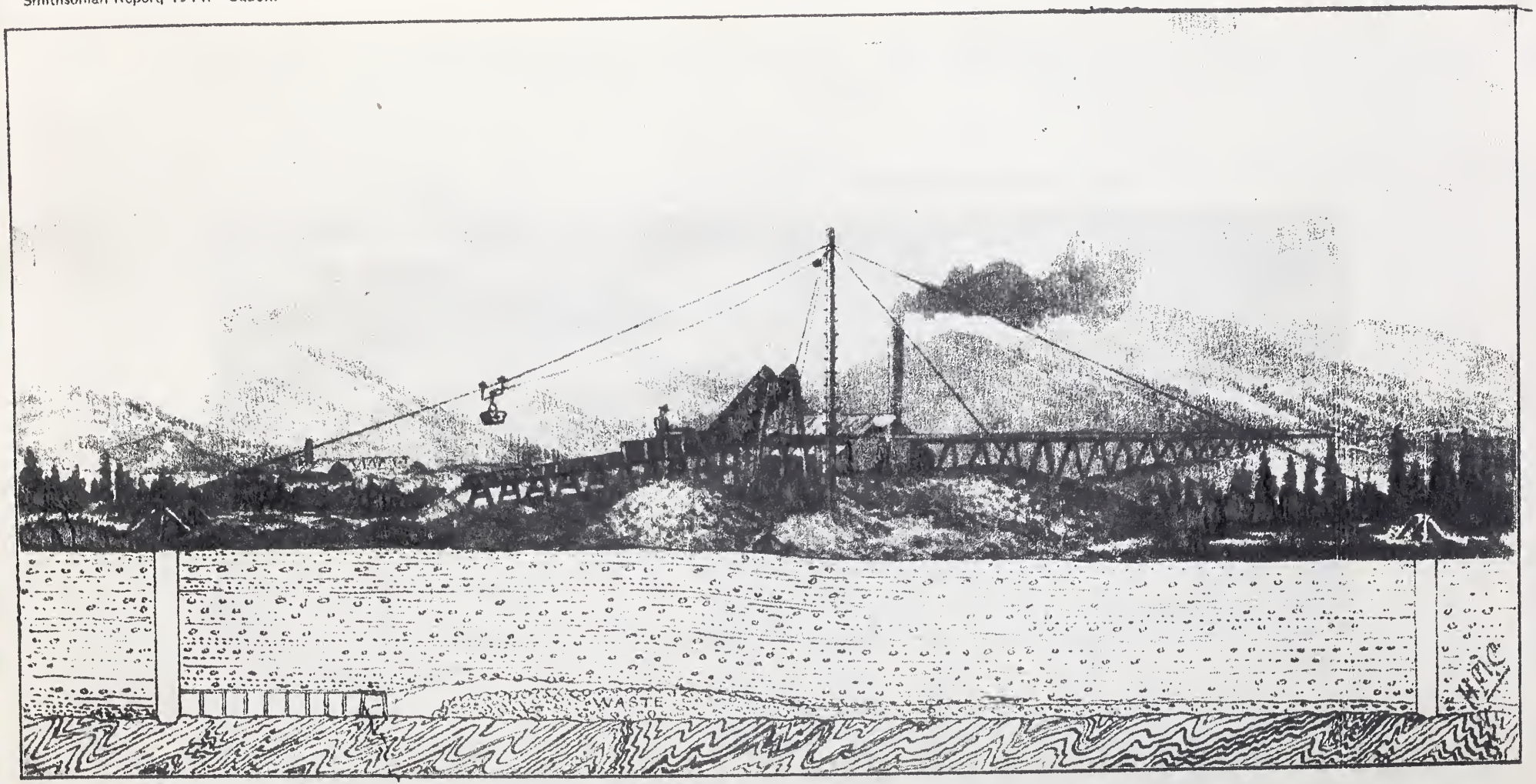
We are often told by politicians of a certain class that wealth is the result of manual labor only. Here we find a notable proof that such shallow philosophy is based on a pure fallacy. The laborers got all they could and wasted most of it. It was only when capital and brains, and especially the latter, came to the rescue that the Klondike goldfield was saved from absolute extinction and granted a new and prosperous lease of life.

The price of the dredger does not, however, nearly represent the whole of the capital involved. The plant is worked by electric power derived from the upper part of the Klondike River, as there is not nearly enough local fuel available for steam-raising purposes. The water is taken from the North Fork of the Klondike by the Granville Power Co. and conveyed through a ditch 6 miles long to a point where there is an effective head of 228 feet. By means of turbines and a 10,000-horsepower plant the current is generated at 2,200 volts and stepped up to 33,000 volts. It is conveyed over two main distributing lines, one of which runs down to the mouth of the Klondike River and the other over the watershed to the basin of the Indian River. This great installation supplies electricity, not only to the Boyle Co. dredgers, but to other public and private consumers in the district. As there is neither cheap fuel nor water power in the immediate neighborhood of Dawson City, it is obvious that this source of power and light is of the highest importance to the district.

The greatest achievement in the way of hydraulics is to be seen in the works of the Yukon Gold Co., an American firm belonging chiefly to Messrs. Guggenheim. As there are no local falls to provide water



VIEW NORTHWARD FROM THE DOME TOWARD THE SNOWCLAD OGILVIE RANGE.



SKETCH AND SECTION OF WORKINGS IN FROZEN GRAVELS IN THE LAST OF THE KLONDIKE DRIFT MINES.

for hydraulicking the higher white gravels, this company in 1905 initiated a bold scheme. After three years of very difficult work they succeeded in bringing water at high pressure from the Little Twelve-mile River, a tributary of the Yukon with a good fall, from a point 64 miles from the Klondike placers. The water is conveyed in 37 miles of ditch, 15 miles of flume, and 12 miles of pipe line, crossing five depressions, including the Klondike Valley, mainly by means of inverted syphons. The water is delivered to the Bonanza terraces under a head of 500 feet. The total length of this waterway and its extensions is 75 miles, and the stream issues from the nozzles at a pressure of 100 pounds per square inch or more.

The "giants" or "monitors," as they are called at some places in America, throw the water against the frozen cliff, and it takes some time to make an impression on a block of the white icy conglomerate, as I soon found when I tried my hand at it. Every day in summer some of the face crumbles away as the ice melts, but the parts that are hard frozen are not quickly eroded down by the powerful jet that is concentrated on them.

The gravel and bowlders are washed into steep and narrow cuts or ravines sunk in the rock-floor of the terrace, with mouths opening on the steep hillside. The gold is caught in wooden flumes and sluice boxes through which the tumultuous current rushes before it spouts out on the face of the slope and is discharged into the gully in the way I have already described. The hydraulicking of these high gravel cliffs with vast jets of snow-white water, like graceful comets, is the most picturesque and striking spectacle in the whole district. (See pl. 5.)

The last of the seven systems of gold working, the mining of the quartz reefs from whose decay the placer gold has been derived, is not important. No large veins have been discovered, but more prospecting may yield some fruits in the future after other methods have been exhausted. On our way down from the Dome we stopped at Victoria Gulch, a small branch near the top of Bonanza Creek, where a prospectors' four-head battery, worked by electric current from the Granville power line, was crushing ore from an open-cast mine about 1,000 feet up the hillside. The Lone Star mine is in a considerable body of low-grade ore in mica schist full of quartz lenticles. It appeared to be about 200 feet wide, but its dimensions were not well defined. The ore did not average more than $3 a ton in value, but assays had proved that at places it contained over 2 ounces per ton, and the prospectors said they were able to pay their way from the proceeds.

The hillsides are covered with scrubby vegetation growing on the decomposed and crumbling rock, and thus the outcrops of mine-

lodes are not always easily discovered. From the quantity of gold in the gravels which are derived from the parts of the local rock surface that have been denuded away, it is likely that the undecomposed rock beneath contains much more, but unless lodes are found in a sufficiently concentrated form at any one place they can not be profitably mined. Hitherto the attention of miners has been mainly directed to what is immediately payable, but further research may reveal large bodies of pay ore in the little explored district. The great and highly profitable Alaska Treadwell mine on the coast near Juneau has laid open an immense body of low-grade ore, but the conditions are far more favorable for cheap mining than they are likely to be at Dawson for a long time to come.

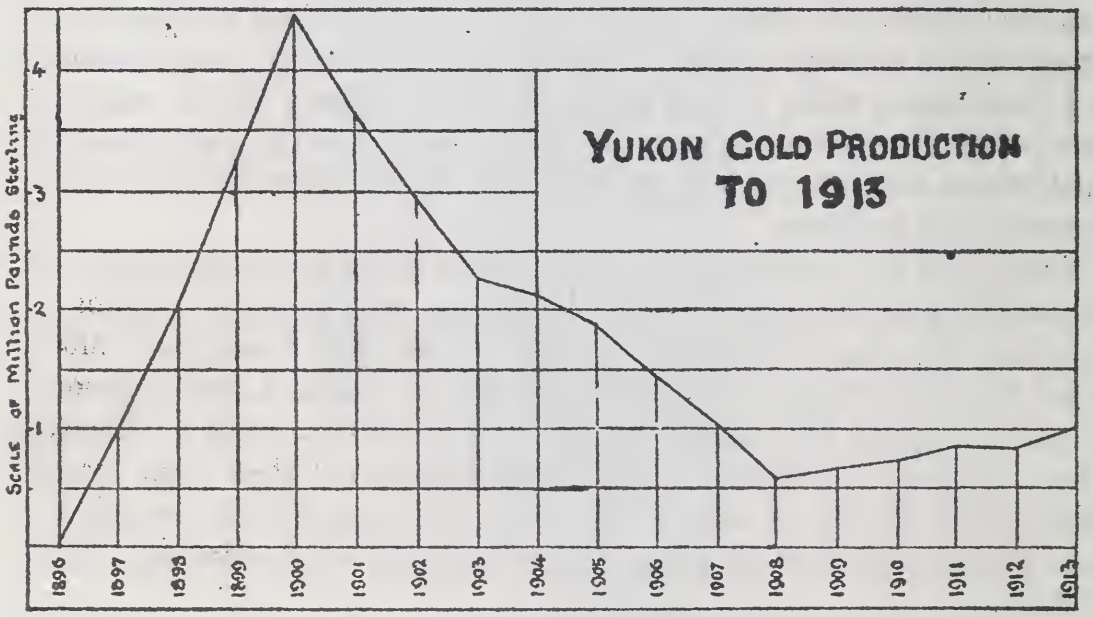


FIG. 5.—Yukon gold production to 1913.

In conclusion it may be noted that although the Yukon and Klondike district is not now producing sensational results, the production from the placers is still large and steady. The exact annual production prior to 1904 is only estimated, but the figures from that year are officially known and have been kindly supplied me by Mr. Edmund E. Stockton, the inspector at Dawson. The Government levies a royalty of 2 per cent on the value of the gold. This is carefully collected, sometimes with the help of that admirable force, the Northwest Mounted Police (mainly recruited in the Old Country) who work more "for honor and applause" than for financial reward, and have, with a small but highly efficient and thoroughly respected personnel, been the means of maintaining a wholesome respect for British law and order in the vast Northwest territory during and since the very trying time of the first great rush of wild adventurers to the Klondike.

The gold production from 1898 to 1913 was as follows. The first column is in dollars and the second is the approximate value in pounds sterling, reckoning £1 as roughly equal to $5. The years in question end March 31.

Yukon gold production.

1898.....	$10,000,000=	£2,000,000	1906.....	$7,166,617=	£1,433,323
1899.....	16,000,000=	3,200,000	1907.....	5,141,136=	1,028,227
1900.....	22,275,000=	4,455,000	1908.....	2,820,131=	564,026
1901.....	18,000,000=	3,600,000	1909.....	3,260,364=	652,073
1902.....	14,500,000=	2,900,000	1910.....	3,594,893=	718,978
1903.....	12,250,000=	2,450,000	1911.....	4,125,570=	825,114
1904.....	10,500,000=	2,100,000	1912.....	4,024,245=	804,849
1905.....	9,306,675=	1,861,335	1913.....	5,018,411=	1,003,682

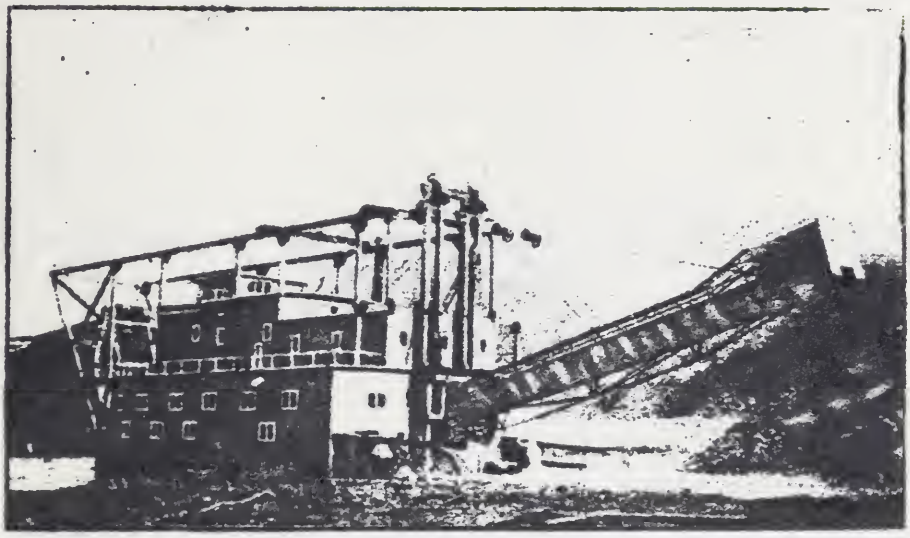
The largest year's output was in 1900, and was estimated at $22,275,000 (£4,455,000), and the total output of the territory since the discovery of gold is estimated at over $150,000,000 (£30,000,000).

These figures, which show the rapid rise and steady decline of the production and the slow increase since 1908 after hydraulicking and dredging operations began, may be made more impressive by reference to figure 5.

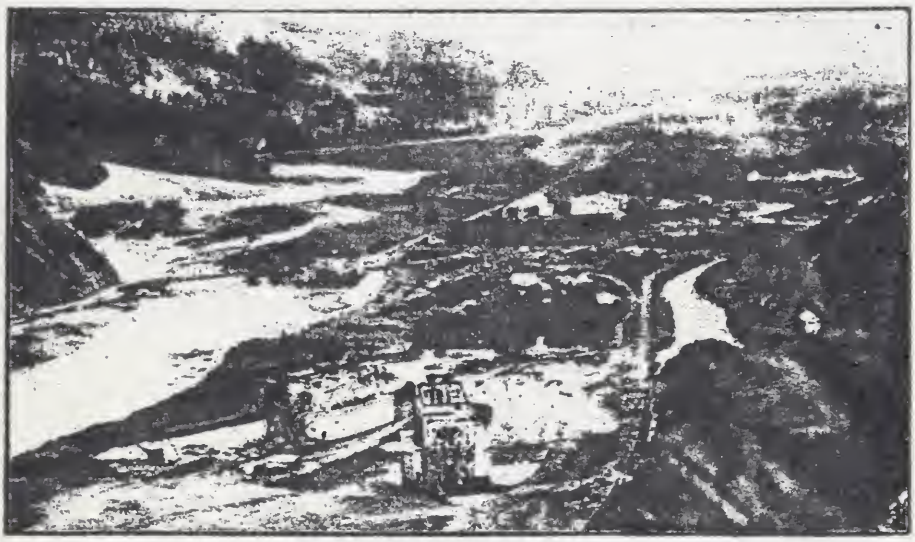
The important question may now be asked: How long is the field likely to remain productive? This aspect of the subject has been discussed by Mr. McConnell in a report published by the Geological Survey in 1907. The total volume of the remaining river and terrace gravel beds was measured and the deposits were carefully sampled in sections. Mr. McConnell's conclusion at that time was that after 1906 the total value of the gold in the Bonanza and Klondike valleys and their tributary creeks was $53,642,620. Since then the value of gold obtained up till the spring of 1913 was $27,984,750, so that of the amount estimated there remained of gold values after 1913 only $25,657,800 still to be produced.

The production in 1913, as shown above, was a little over $5,000,000, and since then the large dredger of the Boyle Concessions has added to the productive capacity of the plant. If Mr. McConnell is right in his figures and no fresh discovery is made, the field at this rate will be quite exhausted in five years' time. But Mr. Boyle has carefully sampled the river gravels at the mouth of the Klondike by boring, and there is evidence that the capacity of the field is considerably greater than Mr. McConnell anticipated. Of course, the life of the field will be shortened in proportion to the rate at which it is being exhausted, and when all the alluvial gold is extracted the main hope for Dawson City will be the discovery of reefs or bodies of payable ore in the bedrock.

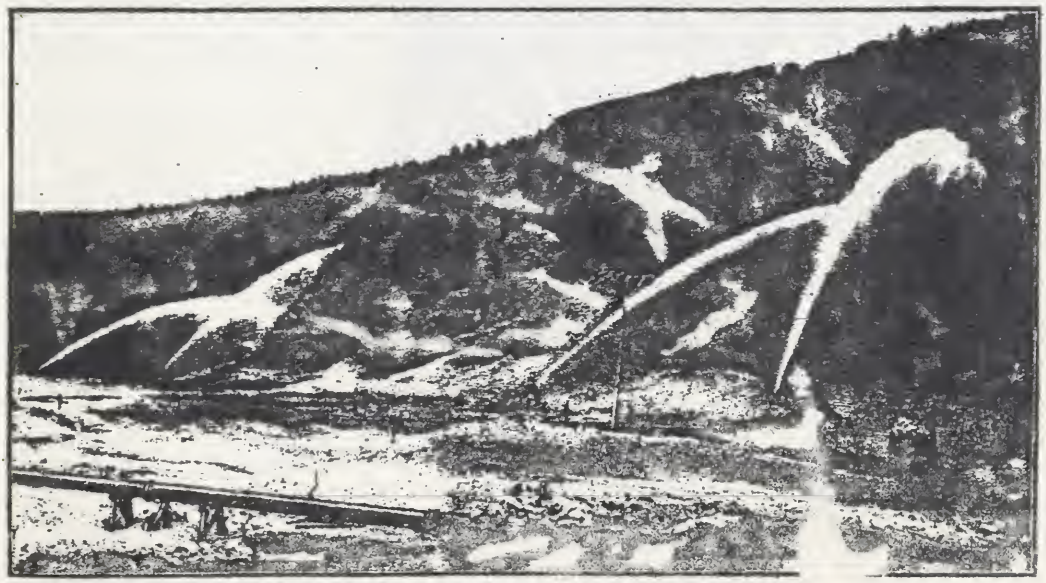
The discovery of gold was the principal means of opening up the Yukon district for settlement and showing that its resources are not entirely dependent on the yellow metal. The vast territory is imperfectly explored, and although it is far north, the climate is warm and favorable for agriculture and grazing in summer. Further exploration is now much easier from such a good center as Dawson City than it was 15 years ago, and we may hope that fresh enterprise will not fail in revealing new resources that will lead to the permanent settlement of this remote and almost uninhabitated outpost of the Dominion.



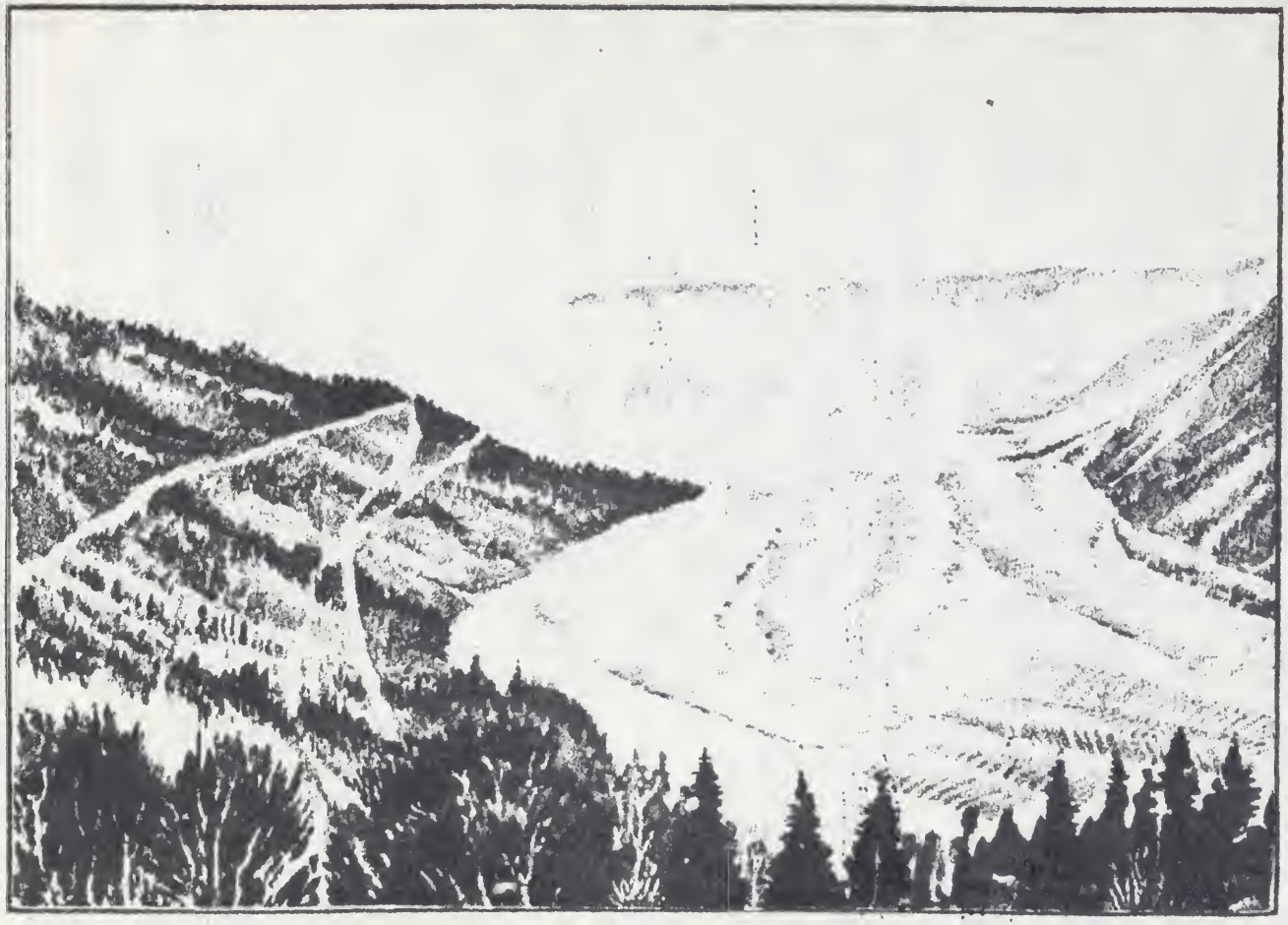
THE LARGEST DREDGER AT KLONDIKE IN 1913.



KLONDIKE RIVER, SHOWING DREDGERS AT WORK.



HYDRAULICKING ON LOVETT GULCH.



EFFECT OF GOLD DREDGING, BONANZA CREEK, KLONDIKE.

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